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INFORMATION ON COAL MINING IN SPAIN

BY

J. H. EAST, JR.

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By J. H. East, Jr.[2]

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7396."

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INTRODUCTION

Very little information regarding coal mining in Spain has been published in the American technical press, and few people realize the extent of this industry or the conditions under which coal is mined. The information in this publication was collected in 1945 and consists of personal observations in Spain, statistics, and other data of a general nature obtained from official sources.

Spain produces bituminous coal, lignite, and anthracite, but the total tonnage mined is less than the national requirements. Before the war, an appreciable tonnage of coal was imported from Great Britain under the Anglo-Spanish treaty, which rebated import duties and effectually prevented competition from any other foreign source. The war stopped the major part of the importation of British coal and caused rapid expansion of the domestic sources, but this was not sufficient to supply the industrial demand. Coal that formerly was not acceptable to industry because of quality is now mined and marketed. The Government allocates the better-grade bituminous coal to the various industries in accordance with the national importance of the work in which they are engaged; for example, the railroads are allotted 100 percent of their requirements, but cement companies can obtain only 25 percent.

The Government offered inducements to increase the production of coal of any class, but the larger part of the increased tonnage obtained was in inferior grades; as a result, the lignite production was taxed, while a bonus was paid for bituminous-coal production in excess of the 1942 tonnage.

The anthracite and bituminous-coal areas were severely damaged during the Civil War, and many experienced miners migrated to the lignite mines in eastern Spain. This has resulted in an acute labor shortage, particularly in the Province of Oviedo where the most important bituminous-coal deposits are located.

Bituminous-coal, anthracite, and lignite deposits are found in several provinces, but the largest and best coal fields are in the northern Provinces near the Bay of Biscay (fig. 1). The production from domestic mines

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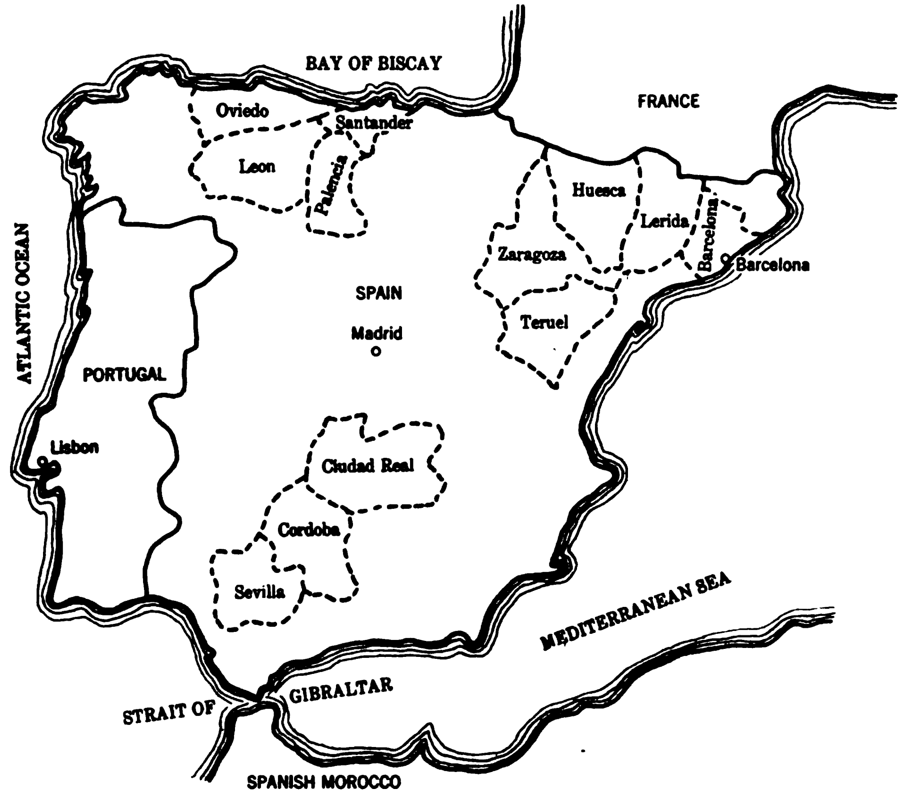

Figure 1. - Provinces in which coal is mined.

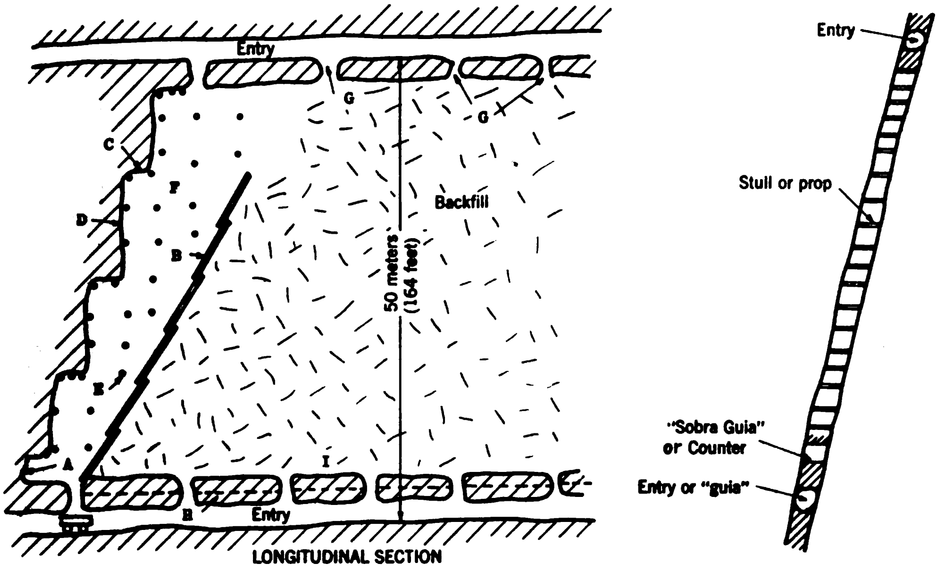

Figure 2. - Usual method of mining, Asturias coal district, Province of Oviedo.

- A. Counter or "sobra guia" is advanced 2.5 meters ahead of mining cut.
- B. Planks.
- C. Length depends on thickness of seam. Ranges up to 5 meters.
- D. 7.5 to 10 meters high.
- E. Stull or mine prop, spaced 1 meter apart.
- F. Stope is worked "open." Miners stand on timbers to work.
- G. Backfill is dumped through opening in pillar.
- H. Lower half of pillar recovered on retreat.
- I. Pillars 5 to 6 meters wide.

is not large if compared to that of some other nations, such as the United States, Great Britain, Belgium, or Germany; however, the increased production obtained in recent years indicates that eventually the coal mines may attain sufficient production for internal use and that Spain probably can cease to be a coal-importing nation.

Table 1 shows the Provinces in which coal is mined, the number of mines, the number of mines producing over 30,000 metric tons annually, and the tons of coal mined in each Province, according to the type of coal.

TABLE 1. - Coal-mining Provinces of Spain in 1944

Province	Total number of mines	Mines producing over 30,000 tons annually	Total coal mined, metric tons
	ANTHRACITE		
Cordoba	3	3	129,594
Huesca	1	0	6,540
Leon	79	6	1,062,610
Lerida	1	0	8,089
Oviedo	30	0	135,356
Palencia	12	0	173,846
Total	126	9	1,516,035
	BITUMINOUS COAL		
Badajoz	1	0	18,105
Burgos	2	0	5,079
Ciudad Real	9	3	844,010
Cordoba	12	2	290,017
Cuenca	2	0	2,143
Leon	79	7	1,390,646
Lerida	1	0	11,624
Logrono	2	0	8,437
Oviedo	123	28	6,000,506
Palencia	3	3	234,043
Sevilla	1	1	164,000
Total	235	44	8,968,700
	LIGNITE		
Alva	1	0	2,965
Baleares	13	0	47,645
Barcelona	24	?	274,508
Burgos	3	0	2,791
Castellon	1	0	7,665
Cuenca	1	0	1,000
Gerona	2	0	11,739
Guipuzcoa	4	0	5,649

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TABLE 1. - Coal-mining Provinces of Spain in 1944 (Cont'd.)

Province	Total number of mines	Mines producing over 30,000 tons annually	Total coal mined, metric tons
LIGNITE (cont'd.)			
Huesca	19	?	54,075
Lerida	39	?	188,484
Murcia	1	0	427
Palencia	1	0	1,788
Santander	3	0	6,748
Teruel	74	12	442,369
Tarragona	4	0	816
Zaragoza	26	?	153,551
Total	216		1,202,220

The annual production of the different types of coal by years is shown in table 2. These official revised statistics are published in the January 1946 Boletin Minero e Industrial.

TABLE 2. - Annual production of coal in Spain, metric tons

Year	Anthracite	Bituminous coal	Lignite	Total
1939	563,963	6,042,264	193,575	6,799,802
1940	1,098,050	7,751,068	568,165	9,417,283
1941	1,169,024	7,606,154	819,186	9,594,364
1942	1,242,932	8,014,256	1,105,561	10,362,749
1943	1,151,762	8,438,816	1,112,016	10,702,594
1944 1/	1,516,035	8,968,700	1,202,220	11,686,955
Jan.-Nov. 1945	1,178,965	6,677,603	969,864	8,826,432

1/ Official tonnage published in Estadistica Minera y Metalurgica de Espana, 1944, by Ministry of Industrial Commerce.

The anthracite is used for household and industrial purposes in the cities of central Spain and along the sea coast; practically the entire anthracite production is consumed in these areas.

The larger part of the lignite production is consumed by the industries in the Provinces of Aragon and Cataluna; these industries include cement plants, textile mills, ceramic plants, and power. The mines are small and are being expanded rapidly.

Bituminous coal, which constitutes the major part of the domestic coal production, is used by the steel plants, railroads, the merchant fleet and other industries. The Province of Oviedo produces about 65 percent of the coal mined in Spain, of this about 98 percent is bituminous coal and the remainder is anthracite.

ASTURIAS BITUMINOUS-COAL FIELD

The Asturias bituminous-coal field in the northern part of Spain is in the Province of Oviedo, historically known as Asturias; the area is mountainous, and its physical appearance resembles that of the anthracite region in Pennsylvania. The area has been folded, faulted, and eroded, and the only coal beds remaining are found in the synclinal basins. The age of the formation is reported as Carboniferous by the Institution de Geologica. The coal is of coking grade and generally soft and friable; in many places the entire coal bed appears to have been crushed. The district produces practically all of coking-grade coal mined in Spain, and the mines have been in operation nearly 100 years.

The number of coal beds of minable thickness occurring in this district is not known definitely, but one of the larger mines extracts coal from 25 different coal beds. Some companies name the coal beds, others number them, and no attempt is made to identify all on a regional basis. The thickness of the coal beds ranges from a few inches to 6.5 feet (2 meters), and there is frequently a wide variation in the width of the same bed in any one mine. The thickness of the beds worked ranges from 12 inches to 6.5 feet, with occasional places where the thickness is greater. One thickness of 8.5 feet was observed, which included a small amount of divider. The dip of the coal beds varies from vertical to about 20° from the horizontal, but the average dip is reported to be 70° to 80°.

The divider between the beds of coal includes hard shales, limy shales, and a conglomerate which grades into a coarse-grained sandstone. The conglomerate, which is called "pudinga," serves as a marker for determining the sequence of the coal beds. All of the mines in the district give off considerable methane and in the United States would be rated as gassy.

Mining Methods

The steeply dipping coal beds are mined by a modified longwall method resembling the practice at the Miller mine in the State of Washington.[3] Vertical shafts are sunk; crosscuts or levels are driven to intersect the various coal beds; and entries are turned right and left from the crosscut and driven along the strike of each coal bed of minable width (fig. 2). The coal beds are not constant in thickness and sometimes are faulted, or thin to less than a minable thickness; these factors usually determine the length of panels. Practically all steeply dipping workings are backfilled. The levels or crosscut tunnels are driven at irregular vertical intervals, depending on the dip of the coal beds, and the levels are generally connected with raises. If the linear distance along the coal bed between levels is too great for economical working, intermediate levels are driven, and the coal is mined by the same method. Usually 50 meters

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[3] Peele, Robert (ed.), Mining Engineer's Handbook: 3d ed., 1941, pp. 10-509

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(167 feet) is regarded as the most efficient working distance between levels. A counter, or ventilation entry, is driven above the main haulage entry in some cases, but this is not the usual practice. Pillars 16 to 20 feet wide (5 to 6 meters) are left over the main entry, and a floor pillar 6.5 to 10 feet wide (2 to 3 meters) is left to support the floor of the higher level (fig. 2). The face of the longwall is worked in steps 25 to 33 feet high (7.5 to 10 meters), and the steps are maintained 4 to 5 meters long (13.5 to 16.5 feet) as a protection to the miners from material falling from a higher step. Stulls or timber supports are placed at 1-meter intervals in a more or less regular pattern.

The coal is mined with small, compressed-air-driven picks, which resemble small paving breakers and weigh about 12 pounds; plain pointed moils are used. The coal is undercut with the air pick about 2 feet at the bottom of the step, the full height of the face is slabbed off and the coal falls to the chute below and is drawn off by gravity into mine cars. The miner stands on the stulls to mine the coal; the coal immediately over the miner is well-supported with timber and lagging. The air picks are called "martillos picadores."

Chutes are driven through the pillars over the haulage entry at intervals of 20 to 24 feet (6 to 7 meters). If the coal dips steeply enough, the chute opening is placed directly over the loading track, and a gate permits the coal to fall directly into the car. In flat-dipping coal beds, loading chutes with a movable lip that will reach to the loading track are placed in the side of the entry. Occasionally, for short distances, the coal beds are too flat for the coal to move by gravity; in this case it is hand-shoveled to the steeper part of the coal bed. No shaking conveyors and only a few metal chutes were observed.

Backfilling is practiced in all cases except when the dip of the coal beds is too flat for the backfill material to move by gravity, which generally is about 30° from the horizontal (fig. 3). The backfilling has effectually prevented subsidence so far as observed; the mine workings extend under villages and under several small streams. The backfill material is obtained by utilizing the refuse from the coal-cleaning plants and from the rock removed while mining the thin coal beds.

Haulage

The main haulageways from the coal beds to the hoisting shafts are always rock crosscuts; the crosscuts range in size from 9 by 10 feet to 10 by 12 feet and are usually heavily timbered and lagged. Some of the mining companies are experimenting with concrete-block linings, following the German practice. Many of the crosscut tunnels are lined with brick at the intersection with the coal beds, and the shaft landings or stations of all mines visited were brick-lined.

The coal cars have a capacity of 900 to 1,100 liters and are said to hold 1 to 1.25 tons of raw coal. The cars are not fully loaded and

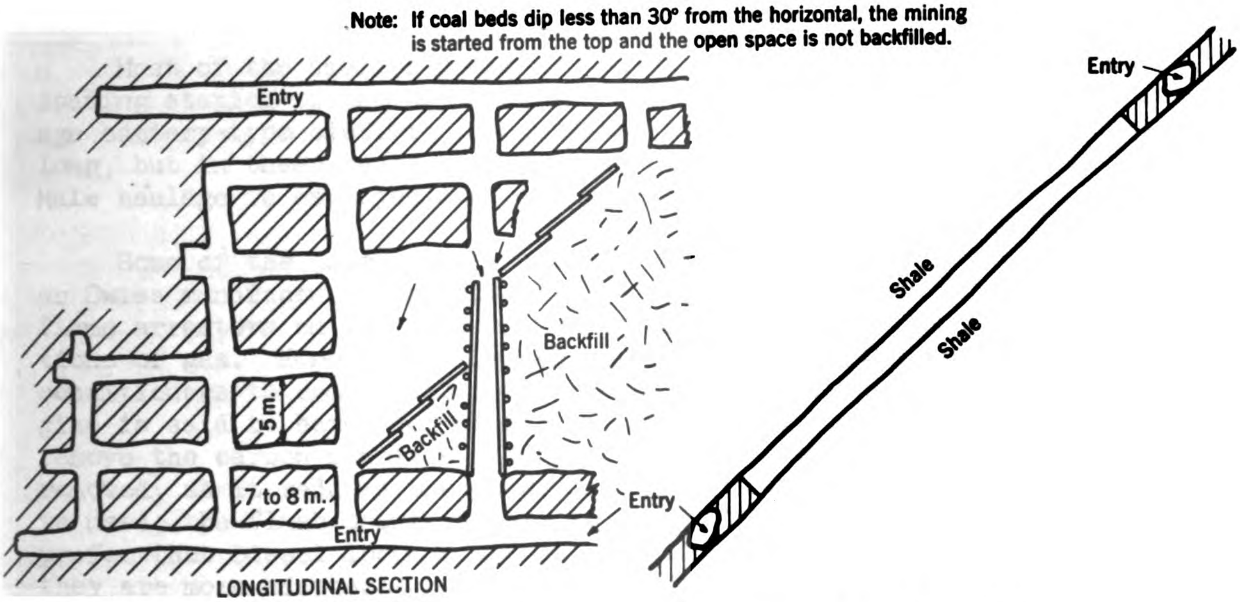
Note: If coal beds dip less than 30° from the horizontal, the mining is started from the top and the open space is not backfilled.
Entry
Backfill
Backfill
5 m.
7 to 8 m.
Entry
Entry
LONGITUDINAL SECTION
Entry
Shale
Shale

Figure 3. - Mining method for coal beds dipping from 30° to 60°, Asturias coal district, Province of Oviedo.

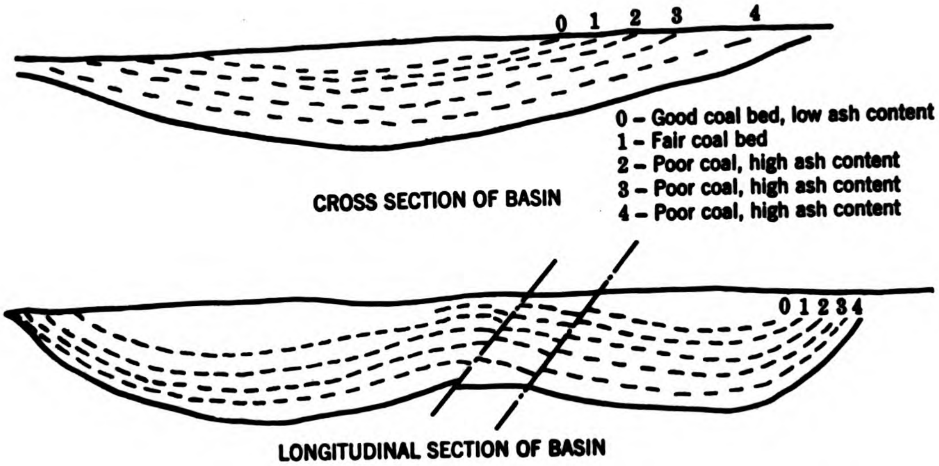
0 1 2 3 4
0 – Good coal bed, low ash content
1 – Fair coal bed
2 – Poor coal, high ash content
3 – Poor coal, high ash content
4 – Poor coal, high ash content
CROSS SECTION OF BASIN
0 1 2 3 4
LONGITUDINAL SECTION OF BASIN

Figure 4. - Coal beds, Puertollano district, Province of Ciudad Real.

are never "topped." The mine cars are generally in poor mechanical condition, as materials cannot be procured with which to repair them owing to war conditions in Europe.

Most of the smaller mines use mules to transport the coal from the loading station to the hoisting shaft; a few mines use trolley-and-storage battery-type electric locomotives when the haulage distance is very long, but in these cases all electric haulage is kept on intake air. Mule haulage is employed almost exclusively in the entries.

Some of the larger mines use Diesel locomotives of French, German, or Swiss manufacture; the locomotives are equipped with labyrinth-type flame arresters on the exhaust to prevent ignition of possible accumulations of gas. None of the Diesel locomotives observed are equipped with conditioners to remove the toxic gases from the exhaust fumes. One engine is said to have been equipped with a gas-absorbent cartridge to remove the carbon monoxide and oxides of nitrogen, but the device was removed, as it reduced the power of the engine. A very light fuel oil is used; the flash point is said to be 125°-130°F. The mine officials prefer that Diesel locomotives be used in place of electric types, as they are more adaptable to changing mining conditions. It is probable that the workmen are not affected by the exhaust gases from the engines because of the relatively large cross-sectional area of the haulage tunnels and because use of the engines is limited to intake air.

Shafts and Hoisting Equipment

All shafts observed were either circular or elliptical in cross section and lined with brick or concrete blocks. The diameters of the shafts range from 16.5 to 20 feet (5 to 6 meters), and the hoisting compartments are placed across the diameters; the ladderways are placed on one side of the hoisting compartments and the pipe compartments on the other.

Single- and double-deck cages are used at the various mines to hoist two to eight mine cars at one time. The sides of the cages are covered with steel netting to a height of 5 feet, but the cages are not equipped with end gates or safety chains, and the loaded cars are not locked in position or blocked on the cage while being hoisted.

Steel rails weighing about 40 pounds a linear yard are used almost exclusively for shaft guides. The position of the guides in relation to the cage varies in different installations; some mines place both guides on one side of the compartment while others follow the conventional method of placing one guide on each side.

Safety catches, or "dogs," on cages are not in general use. The opinion of many mine officials is that safety catches will not function effectively, particularly if the hoisting rope fails while the cage is descending. Shaft chairs are provided at the collar and bottom of the hoisting shaft but not on the intermediate levels.

The mine hoists are usually electric-driven and equipped with cylindrical or semiconical drums, and all have overspeed and overwind safety devices of German manufacture. Most of the mine hoists are equipped with two independently operated brakes; one brake functions on a drive-shaft drum and the other on a brake drum attached to the flanges of the hoist drum. A recording device makes a graph showing the number of trips in 24 hours, the hour when the trip is made, the speed of hoisting, and the time required for the trip. These graphs are filed and reviewed periodically by the Inspector of Mines.

The hoisting ropes are usually 6 by 18 construction, with hemp cente are up to 2 inches in diameter, and are manufactured in Spain. They are attached to the cage by clamping the rope around a thimble and suspending the cage from the thimble with four to six chains, depending on the length of the cage; Crosby-type clips or spelter-filled sockets are not used. The hoists observed can hoist from much greater depths than the present working levels.

The hoisting ropes are cleaned with steam and inspected once each month while the rope is new and at more frequent intervals when it is older. The accepted rule for removing hoisting ropes from service is to count the number of broken wires in 1-meter length of rope, and if more than 10 percent of the wires in the strands are broken the rope is considered unfit for use and is changed. No attempt is made to lubricate the rope internally with a light oil, but a heavy shield lubricant is applied to the rope at the collar of the shaft. Most mining companies cut 5 to 6.5 feet (1.5 to 2 meters) from the cage end of the hoisting rope at 6-month intervals and inspect the rope for internal corrosion. The excess length of rope is coiled inside the hoisting drum at most installations.

Ventilation

The mines of the Asturias district are inadequately ventilated in comparison with recognized American coal-mine practice. The coal-mining law of Spain requires that the air must contain at least 19 percent of oxygen in all of the working sections of the mines, and 85 cubic feet of air per minute (40 liters per second) must be supplied each worker. Mules are counted as three men for ventilation requirements, and internal-combustion engines must be supplied with 380 cubic feet of air per minute (180 liters per second). The ventilating air is measured at the collar of the intake-air shaft, but the volume of air passing along the working face is not measured. It is believed that the mining law is not strictly enforced. Haulage tunnels in mines using Diesel or electric locomotives are always well-ventilated.

Compressed-air-driven blower fans with 8- and 10-inch steel tubing are used to ventilate "dead-end" drifts and when driving raises between levels.

Safety Lamps

Each crew of men working underground is provided with at least one safety lamp to test for gas; timbermen and miners were observed testing for gas in their working places.

The safety lamps have a double gauze of 28-mesh. The gauze is surrounded with a shield of solid steel plate, with air passages at the top of the shield and below the wick. The lamps are not locked and can be opened readily at any time.

Portable Electric Lamps

Electric hand lamps of Spanish manufacture are used throughout the district, and are similar in design to those manufactured in Germany. Mine officials say that hand lamps are preferred to the electric cap lamps commonly used in the United States. The battery is of the acid type, and the light bulb is placed directly above the battery and covered with either a frosted or corrugated glass shield that prevents glare. A metal handle shaped like a large hook is used to carry the lamp. It is employed to hang the lamp from a timber; or, when the miner requires the use of both hands, as when climbing into a stope, the hook is placed around the miner's neck to carry the lamp. A lamp without the handle is about 11 inches high. It gives 10 hours of service and requires 10 to 12 hours for recharging. Some mine officials say that the hand lamps now in use are unsatisfactory and will be replaced when it is possible to do so.

Explosives

A relatively small quantity of explosives is used in the Asturias district, since approximately 80 percent of the coal is mined with air picks. The use of explosives is limited to driving rock tunnels and to blasting divider between narrow coal beds on development work.

Blasting caps and fuse are employed to fire the explosives. The blasting caps are rated as No. 3, but it is not certain if the same system of numbering blasting caps by strength is used in Spain as in American practice.

The explosives used in the mines in this district are manufactured in Spain and the types, names, and composition are listed below:

Coal	Seguridad No. 7	Percent
	Nitroglycerin	11.76
	Ammonium nitrate	88.00
	Nitrated cotton	.24
	Total	100.00

Rock and Coal	Seguridad No. 2	Percent
	Nitroglycerin	29.10
	Ammonium nitrate	70.00
	Nitrated cotton	.90
	Total	100.00

Rock	Goma No. 2	Percent
	Nitroglycerin	26.00
	Ammonium nitrate	60.00
	Dinitrotoluene	12.00
	Nitrocellulose	1.60
	Cellulose	.40
	Total	100.00

Use of Compressed Air

Compressed air is used underground for power purposes to a much greater extent than in American coal-mining practice; most of the compressors observed are of American manufacture and electrically driven. The compressed-air mains in the mines are usually 6- to 8-inch-diameter flanged pipes and are well-maintained. The pipes are supported from the roof of the haulage tunnels with steel hangers.

The mining companies have been unable to obtain additional compressors of American manufacture during the war years, but the number of air picks in use has greatly increased; consequently, the air pressure at all the mines visited was too low for efficient operation. Several mines have large compressors partly erected but have been unable to obtain the remaining material for completing the installations. Most of the mines could increase production 10 to 20 percent if additional air compressors could be obtained. One large mine has five compressors totaling 1,800 horsepower, the sixth compressor (with a 450-horsepower motor) is partly erected, and the company has been waiting more than 2 years for the rest of the shipment.

The compressed-air picks are of European manufacture, chiefly German, and are designed to operate efficiently on lower air pressure than American air drills. They weigh about 12 pounds. At present, many miners are required to use hand picks to mine coal, but this is slow and expensive in this type of mining.

Blower fans, driven by compressed-air motors, are used exclusively for ventilating "dead-end" workings and when driving raises; some fan installations to ventilate longwall faces are unable to operate due to lack of adequate air-compressor equipment.

Coal-Cleaning Plants

The mine-run coal produced in the Asturias district has a high-ash content ranging from 30 to 50 percent; as a consequence, most of the coal is washed before marketing.

The coal is marketed in six sizes, as follows:

Size of coal, mm.	Spanish name of product	Percent of total at a typical mine
Plus 60	Cribado	9.7
-60 plus 30	Galleta	12.5
-30 plus 15	Gransa	15.7
-15 plus 10	Grancilla	1.7
-10 plus 2	Menudo	53.4
- 2 plus 0.2	Fino	7.0

All sizes larger than 2 mm. are washed in Harz-type jigs to remove the slate and shale. The minus 2-mm. size is treated by flotation. The oversize (plus 60 mm.) is cleaned by hand pickers; both men and women are employed in this work. The jigs are manufactured by Miguel de Prada at Valladolid in the Province of Leon. Quartz pebbles are used as a bed for the jigs; the pebbles are 1.5 to 2.0 inches in diameter, and the jig beds are 2.5 to 3.0 inches thick.

The minus 2-mm. coal is taken to a flotation plant, which is equipped with Minerals Separation flotation cells. Creosote is used as the reagent, and 1.5 to 2.0 kg. are used in treating 6.0 tons of pulp. The average cost of creosote is 1.5 pesetas a kilogram which, at the present exchange rate of 10 pesetas equals $1.00 U. S. currency, is 15 cents a kilogram, and the reagent cost is 3.75 cents to 5.0 cents per ton of pulp. The flotation product is filtered and partly dried in a kiln, then it is mixed with the minus 10-mm. plus 2.0-mm. coal for coking.

The slate and shale rejects from the washing plants generally are taken into the mine for backfilling; the material is hauled underground in mine cars during normal mine operation.

Details of Individual Mines

Company: Sociedad Metalurgica Duro-Felguera
Capitalization: 125,000,000 pesetas
Production, total company: 1942 .... 1,439,370 metric tons
1943 .... 1,547,200 metric tons

Soton shaft
Location: near village of La Felguera, Province of Oviedo
Daily production: Mine-run coal ... 1,040 metric tons
Washed coal ..... 800 metric tons
Dip of coal beds: About 75° from horizontal
Shaft No. 1 - Depth: 220 meters (722 feet)
Diameter: 5 meters (16.4 feet)
Lining: Concrete
Cage capacity: 2 mine cars
Cage, number of decks: 1

Shaft No. 2 - Depth: 220 meters (722 feet)
Diameter: 3.8 meters (12.5 feet)
Lining: Concrete
Cage capacity: 1 mine car per deck
Cage, number of decks: 2
Distance between levels: 50 meters (164 feet)
Spacing of loading chutes through pillars: 7 meters (23 feet)
Haulage: Trolley-type electric locomotives used in crosscut tunnels
Haulage: Mules used in entries

Mosquitera Mine
Location: Near village of La Felguera, Province of Oviedo
Daily production: Washed coal - 1,400 metric tons
Dip of coal beds: Averages 80° from horizontal
Mining 25 different coal beds ranging from 12 inches to 6.5 feet thick
Shaft - Depth: 853 feet (260 meters)
Diameter: 18.4 feet (5.6 meters)
Lining: Concrete
Cage capacity: 4 mine cars
Vertical distance between levels (shaft depth): 131, 492, and 853 feet
Intermediate levels are not connected with main shaft.
Haulage: 8-, 12-, and 14-ton, trolley-type, 250-volt, electric locomotives are used, but only where ventilation is very good.
Haulage: Mule haulage used on intermediate levels
Car capacity: 1 metric ton
Hoist: 500-hp. double-drum electric
Hoist: Drums are 13 feet (4 meters) in diameter
Air compressor capacity: 7,000 cu. ft. per minute.
Air pressure: 60 pounds per square inch
Pumps: Electric; 1,300 g.p.m.
Lights: Hand-type electric

Average analysis of washed coal

	Plus 30 mm.	Minus 30 mm.
Fixed carbon	58.90	58.80
Volatiles	35.35	35.50
Ash	5.75	5.70
Sulfur	1.17	1.26
B.t.u.	13,725	13,475

Company: Hulleras de Turon (subsidiary of Altos Hornos de Viscaya de Bilboa)
Capitalization: 20,000,000 pesetas
Location: Near village of Turon, Province of Oviedo

Normal production: 675,000 tons annually (washed coal)
All but 10 percent of production is shipped to company-owned blast furnaces at Bilboa.
Daily production: Mine-run coal ..... 4,000 metric tons
Washed coal .... 2,400 to 2,500 metric tons
Dip of coal beds: About 80°. from the horizontal
Coal beds are 15 inches to 6.5 feet thick (0.4 to 2.0 meters)
Shaft - Depth: 623 feet (190 meters)
Diameter: 18 feet (5.5 meters)
lining: brick
Haulage: Diesel locomotives on main lines
Mule haulage used in poorly ventilated workings.
Power: Electric power general purchased, but company has a 20,000 kw.-h. plant as a stand-by
Coal: Mine-run coal contains 47 to 50 percent ash
Washed coal contains 10 to 12 percent ash
Flotation product contains 12 percent water after vacuum filter. This product is mixed with 1- to 10-mm. size coal for coke-oven feed.

Average washed-coal analysis:

Volatile matter	25 to 27 percent
Ash	5 to 12 percent
Sulfur	1.1 to 1.35 percent
B.t.u.	13,320 to 14,400

Company: Fabrica de Mieres, S. A.
Location: Village of Mieres
Production: 32,000 metric tons of washed coal a month.
About 25 percent of production is used in company-owned blast furnaces at Mieres, and the remainder is sold.
Production could be increased to 40,000 metric tons a month if more air compressors could be obtained.
Shaft: Barredo pit.
Vertical distance between levels, (shaft depth): 131, 394, and 656 feet.
Each level is estimated to produce 5,000,000 tons of washed coal
Haulage: Diesel and electric locomotives in main haulage levels and mules in workings where the ventilation is not well-maintained
Timber: Approximately 154 pounds (70 kilograms) of timber is used per ton of washed coal produced
Uses electric methane detector, trade name "Dominit." It is said to be very accurate.

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Average analysis of washed coal

	Plus 30 mm.	Minus 30 mm.
Fixed carbon	63.15	63.30
Volatile matter	33.40	32.00
Ash	3.45	4.70
Sulfur	.93	1.55
B. t. u.	14,580	14,640

Company: Sociedad Hullera Espanola
Capitalization: 40,000,000 pesetas
Location: Village of Ujo, Province of Oviedo.
General: Almost all of the coal beds of Asturias district occur in this mine. Mine was opened in 1893.
Production: 60,000 metric tons of washed coal a month
Principal mine shafts:
  San Jorge: 512 feet (156 meters) deep
  San Antonio: 984 feet (300 meters) deep
  Santiago: 1,425 feet (465 meters) deep
Washing-plant capacity: 200 tons per hour
Daily production of washed coal: 2,200 metric tons
Ratio of washed coal to mine-run coal is about 67 percent
Air compressors: 20 air compressors are in use; rated horsepower is 2,354 hp.

Several American-manufactured air compressors are ordered and initial payments are reported to have been made, but delivery cannot be obtained.

More compressed air is badly needed at this mine.

Lights: Dominit hand-type electric lamps.

Larger part of mine production has been requisitioned by the government for use by the State-owned railroads. The price paid for this coal is stated to be less than the cost of production.

Average analysis of washed coal (steam coal)

	Plus 30 mm.	Minus 30 mm. plus 10 mm.
Fixed carbon	77.90	77.30
Volatile matter	17.75	18.25
Ash	4.35	4.45
Sulfur	1.12	1.20
B.t.u.	15,100	15,275

Labor Situation

The labor situation in the Asturias district is rather critical. The wages of the miners have not increased as rapidly as the commodity prices; consequently, the miners in the lower pay brackets are very dissatisfied. The work period is normally 7 hours a day for underground employees and 8 hours a day for surface workmen; at present the underground employees work 8 hours a day and are paid overtime for additional time worked. The miners give the Fascist salute to supervisory officials on meeting them or when the officials pass their working place.

The wages of the miners are determined by several unusual factors; the lowest-paid workman in the mine receives 9.50 pesetas ($0.95 U. S. Cy.) a day as a base wage. The air-pick miners (pickaderos) and other skilled laborers receive up to 24 pesetas ($2.40 U. S. Cy.) a day as a base wage. The employees are paid for Sunday, but are not required to work that day; this is accomplished by paying 1-1/6 days' wages for each day worked. For example, a miner works 6 days and receives 6 x 1-1/6 days' pay, or 7 days wages; if the miner works only 5 days the pay is 5-5/6 shifts. If a miner is required to work on Sunday the pay is 2.40 times the regular pay.

A bonus system is paid to assist in overcoming the increasing cost of living and to help to reduce absenteeism. Every employee is paid 2.50 pesetas ($0.25 U.S.Cy.) a day to come to work, but if one day is not worked in the period, the bonus for the entire week is forfeited.

The miner receives "portal-to-portal" pay. The shift begins when the miner receives a lamp from the lamp house, and is ended when the lamp is returned to the lamp house. Traveling time to the working place is compensated by allowing 10 minutes at base-pay rate for each kilometer (0.6 mile) the working place is away from the shaft landing.

The Spanish law permits boys to start working in the mines at 16 years of age, but they are paid 1.50 pesetas ($0.15 U. S. Cy.) less than the regular base pay for that occupation, or 8.00 pesetas ($0.80 U. S. Cy.) a day until they are 18.

The conscription of young men for service in the Spanish Army has caused a critical shortage of mine labor, particularly in occupations that require young, agile men. The mine operators have tried unsuccessfully to have coal miners exempted from the conscription, because many of the young men that are conscripted do not return to work in the mines on completion of their army service.

Welfare

The mining companies of the Asturias bituminous-coal district provide better than average living conditions for the employees. Many of the houses have small gardens, orchards, and flower gardens around them; the houses appear to be well-maintained, although they are not modern.

The company-owned hospitals provide medical and hospital services for the miners' families, including care of women at childbirth. One hospital has 300 beds and maintains a staff of 30 doctors and dentists; no charge is made to employees for this service.

Employees may buy at a company-owned store or at numerous privately-owned stores in the neighborhood; the company stores are said to operate on a nonprofit basis.

The schools for the children are financed by the mining companies and are said to be better than the average grade schools in Spain. The school play-yards have the usual swings, rings, and slides common to most playgrounds.

Mining companies are paternalistic in the treatment of an employee, since he frequently works his entire life in the same mine or with the same company. Each employee is furnished with coal for domestic use at no cost; this is considered as part of the wages and is a universal custom in Spain.

PUERTOLLANO DISTRICT

The Puertollano coal district is in the Province of Ciudad Real in the southern part of the historical Province of Castilla la Neuva. The mines are near Puertollano, a city of 30,000 population. The principal mining company is the Sociedad Minera y Metalurgica, a French company capitalized at 310,000,000 francs.

The coal field is approximately 7 kilometers long (4.2 miles) and 5 to 6 kilometers wide (3.0 to 3.6 miles). The coal beds occur in a basin having comparatively flat slopes and with only minor faulting. The beds generally dip less than 20° from the horizontal. Five beds of coal are mined, ranging from 1 to 5 meters (3.3 to 16.5 feet) in thickness (fig. 4). Shale and sandstone separate the coal beds, and quartzite forms the floor. The quartzite formation outcrops prominently around the border of the basin.

A bituminous shale occurs near the floor of the basin, under the coal beds. The shale is mined by the S. M. M. de Penarroya from a separate shaft and is treated at the Distilleria de Callatroba. The oil-shale industry is closely regulated by the Government, and an extensive expansion program is contemplated.

The coal is rated as bituminous, but it is noncoking and of an inferior quality as compared to the coal mined in the Asturias district. The average ash content of the five coal beds is tabulated below:

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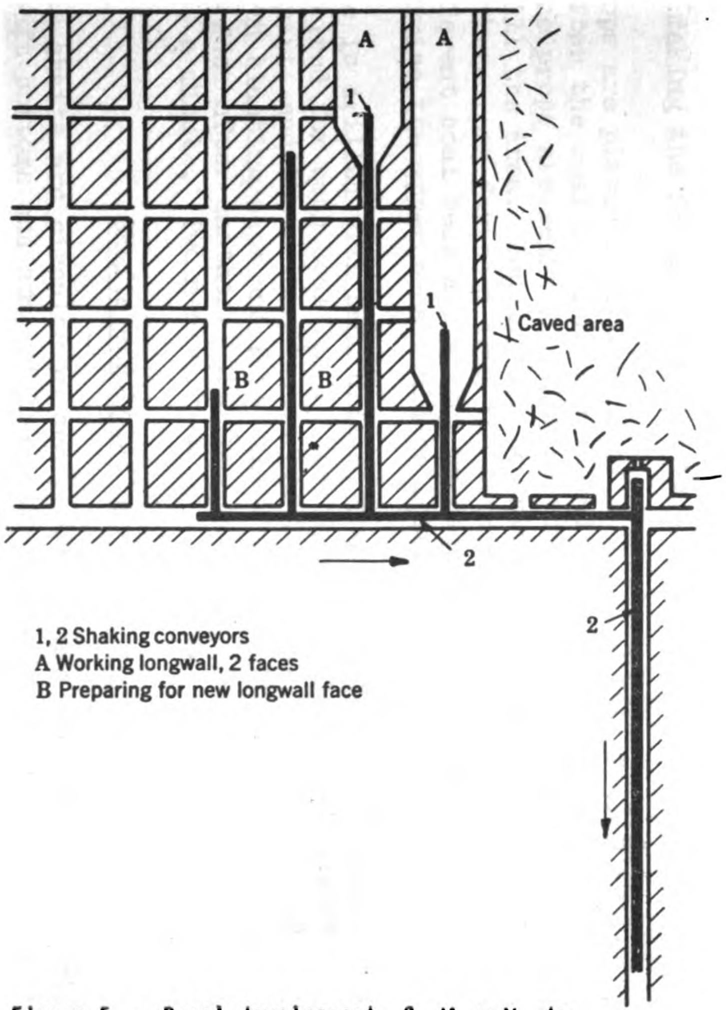
A
A
1
1
Caved area
B
B
2
2
1, 2 Shaking conveyors
A Working longwall, 2 faces
B Preparing for new longwall face

Figure 5. - Panel development, S. M. y M. de Penarroya, Puertollano.

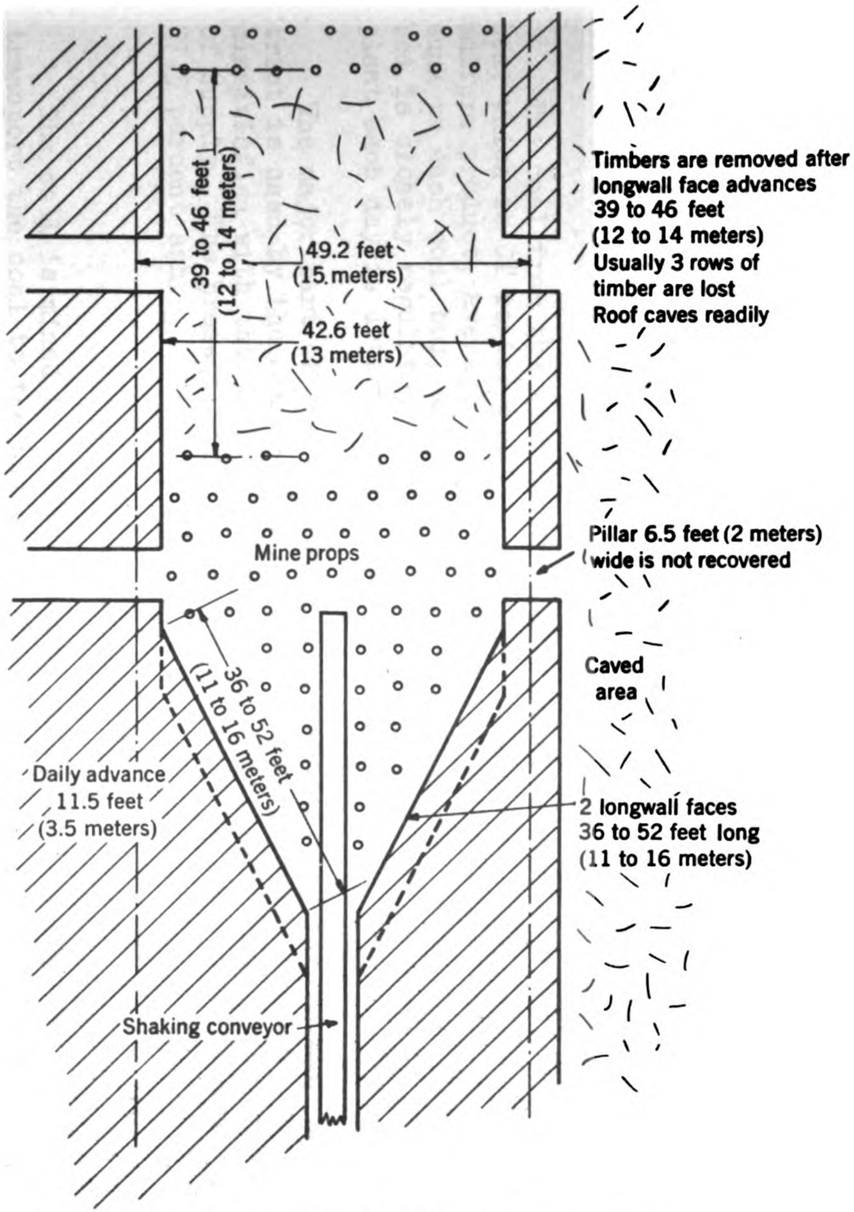

Figure 6. - Block system of mining, S. M. y M. de Penarroya, Puertollano.

Bed No.	Ash, percent
0	17 to 19
1 (3 splits)	(19 to 21
	(30 to 35
	(42 to 47
2	32 to 36
3	32 to 36
4	36 to 40

The coal from the four lower beds is mixed with the coal from "0" bed, which is of better quality, and the washing plants make a fairly uniform product, averaging 15 to 18 percent ash. Individual shafts are sunk to each coal bed, and the tonnage of coal hoisted from each coal bed is closely regulated. The tonnage of coal sent to the washing plant each day is determined by the tonnage mined from the "0" bed.

The major part of the tonnage of coal mined in the Puertollano district is used by the State-owned railroads; the railroad officials are dissatisfied with the quality of coal, but cannot secure any other source of supply. The present State regulations permit railroad coal to contain 27.5 percent ash.

Mining Methods

The coal is mined by a block system, using shaking conveyors to transport the coal to the haulage entry (fig. 5). The entries are driven to the outcrop, or to the mining limit, and the coal is mined on the retreat. The center lines of the rooms or blocks are spaced 15 meters (49.2 feet) apart, and 13 meters (42.6 feet) of coal is mined, leaving a pillar 2 meters (6.5 feet) wide; this coal is not recovered (fig. 6). The faces of the block are maintained at an angle of 25° to 30° from the center line, making the faces 11 to 16 meters (36 to 52 feet) long.

Mine props are placed at intervals of 1 to 1-1/2 meters (3.3 to 5.0 feet), and after the coal faces have advanced 12 to 14 meters (39 to 46 feet) the mine props are removed, allowing the shale roof to cave and completely fill the area. Usually all the mine props are recovered except two or three rows farthest from the working faces. It is essential that the different coal beds are worked in sequence on account of the caving; otherwise the upper beds would be lost.

The face is drilled with hand drills, and an average of 28 drill holes is required for each coal face. The holes are spaced 1.8 meters (5.8 feet) apart, and the rows of holes are staggered. The explosives are fired with blasting caps and fuse; the shots are fired in sequence, igniting one fuse after another. The fuse burns at the rate of 60 cm. (23.5 inches) a minute. Two men work as shot firers.

Shafts and Hoisting

The mine shafts are circular in cross section and are concrete-lined, while the shaft bottoms and some of the entries are lined with brick. All hoists observed were equipped with automatic overwind and overspeed safety devices and with two independently operated brakes, one on the drive shaft and one on the drum flanges.

All the hoisting ropes observed are 1-7/8 inches in diameter. The hoist ropes are inspected monthly, and every 6 months the cage end of the rope is cut off; this interval is less when the rope is old. One company replaces the hoisting ropes after 2 years of service. In this district, hoisting ropes are changed if 10 percent of the individual wires in the strands are broken in any 2-meter (6.5-foot) length. The hoisting ropes are attached to the cage by means of a thimble and chains; the rope is clamped around the thimble with plain clamps; no Crosby-type clips were observed.

Azdrubal Mine

The Azdrubal mine is owned by the S. M. M. de Penarroya and is the largest and most modern mine in the Puertollano district. The Pozo Norte shaft is sunk to the "0" bed and is 205 meters (673 feet) deep. The shaft has two hoisting compartments, a manway and a pipe compartment. The cages are the two-deck type and each deck carries three mine cars. The hoisting speed for coal is 7 meters a second (1,377 feet a minute); men are hoisted at 4 meters a second (787 feet a minute). An automatic safety device on the hoist prevents overspeed, and the cage is stopped automatically at the collar of the shaft.

Transportation

The mine cars have a capacity of 700 liters (25 cubic feet) and hold an average of 600 kg. (1,320 pounds) of coal; the cars are not equipped with bumpers, and the ends of the cars are in contact with each other when the cars are pushed. Chains are used to couple the cars together.

The Pozo Norte mine uses four trolley-type and six storage-battery-type electric and three Diesel locomotives. The Diesel locomotives are rated as 4-ton 24-horsepower.

The Diesel locomotives are equipped with exhaust-gas washers, which contain a solution of sodium carbonate (Na_2CO_3); the exhaust pipes are fitted with wire-screen flame arresters. The Diesel locomotives are used entirely for gathering purposes. The State mining regulations for the district require 4,000 liters (141 cubic feet) of air a second for each locomotive in use. Mine officials say that no trouble has ever been experienced with exhaust fumes from the Diesel locomotives, but that ample ventilating air is provided in the working sections where they are used.

Ventilation

The ventilation of the mine is inadequate as compared to American practice; three air shafts with fans working exhausting induce the ventilating air current; the quantity of air is measured at the surface, but not at the working faces. Mine officials state that the ventilating current is sufficient to provide each underground worker with 60 liters of air per second (127 cubic feet per minute).

General

The Pozo Norte mine produces an average of 1,600 metric tons of coal daily; the maximum output hoisted from this shaft is 1,760 tons. One thousand men are employed underground and 200 on the surface. The entire mining operations of the S. M. M. Penarroya in this district employ 1,470 persons underground and 680 on the surface. The company produces an average of 50,000 metric tons of washed coal a month.

The Azdrubal mine uses approximately 22.5 kg. (50 pounds) of timber for each ton of washed coal produced. One mine in the district uses 60 to 70 kg. (132 to 154 pounds) of timber for each ton of washed coal.

Coal Preparation

The coal-washing plant of the S. M. M. Penarroya at the Azdrubal mine is the only washery in the district. It is old and inefficient, and the company plans to replace it with an enlarged modern plant as soon as it is possible to obtain the equipment. The present plant includes sizing equipment and Harz-type jigs, but not flotation.

The following sizes of coal are produced at the washing plant:

Size of coal, mm.	Spanish name of product	Percent of total at Azdrubal mine
Plus 200	Gonero	3.25
-200 plus 80	Doble cribado	19.55
-80 plus 50	Cribado	8.45
-50 plus 25	Galleta	16.50
-25 plus 15	Avellana	12.90
-15 plus 6	Grancilla	5.50
- 6 plus 0	Menudo	33.85
		100.00

The washing-plant product is not cleaned as well as formerly because of the necessity for obtaining a larger tonnage of coal. In 1936 the washing-plant production averaged 22,000 metric tons a month; the coal contained 15 to 18 percent ash, and the heat value was 13,500 B. t. u. At present, the plant production averages 60,000 tons a month and the ash content of the coal is approximately 25 percent; the heat value averages 12,600 B. t. u.

CLASSIFICATION OF EMPLOYEES

The coal mines of Spain employ a smaller percentage of the underground employees in the actual mining of coal than is customary in American practice. The labor classification of a large mine in the Asturias bituminous-coal district is shown below; this mine is considered to be typical of the district.

Asturias district

Occupation	Percent of total underground employees
Supervisory	1.30
Drillers in rock	13.75
Air pick miners and helpers	27.40
Timbermen	6.80
Trackmen	2.55
Mule drivers[1]	10.20
Muckers in rock	15.50
Shovelers to chute	20.40
Pipemen	.80
Bottom men	.55
Pumpmen	.07
Stablemen	.21
Cablemen	.07
Other	.40
Total	100.00

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[1] Mule driving is regarded as a very dangerous occupation. It is one of the leading causes of fatal accidents.

The coal beds of the Puertollano district in the Province of Ciudad Real are much flatter than in the Asturias district, and the system of mining is different. The labor classification at one of the large mines in the Puertollano district is shown below.

Puertollano district

Occupation		Percent of total underground employees
Supervisory		1.22
Drillers and cutters		6.66
Timbermen:	1st class	1.57
	2d class	7.60
	3d class	9.60
Air-pick miners		14.50
Mule drivers		1.36
Locomotive engineers		1.02
Trackmen:	1st class	1.02
	2d class	2.31
	helpers	3.81
Pumpers, shaft		.88
Bottom men:	shafts	.13
	planes	9.25
Pipemen		3.06
Plasterers		1.50
Trammers		34.30
Total		100.00

The number and occupation of surface plant employees vary widely in the different districts and at different mines; the classification of surface employees at a large mine in the Asturias district is shown below. This mine has the most modern coal-washing plant in Spain.

Surface plant - Asturias mining district

Occupation	Percent of total surface employees
Skilled labor, 1st class	2.50
2d class	7.06
helpers, 1st class	2.50
helpers, 2d class	3.97
Other skilled labor	2.50
Hoisting engineers, 1st class	1.91
2d class	1.75
Locomotive engineers	.58
Chauffeurs	1.38
Labor: Special	8.23
General	41.90
Boys: Age 14 to 16 years	3.82
Age 16 to 18 years	8.39
Age 18 to 20 years	8.58
Women: Slate pickers	3.22
Cleaners	1.76
	100.00

Approximately 45 percent of all underground employees are used in work other than the actual production of coal.

EMPLOYMENT

The total employment of labor in Spanish coal mines has more than doubled in the past 10 years; the employment in lignite mines has increased sixfold. Table 3 shows the number of persons employed in anthracite, bituminous coal, and lignite mines in 1944, as compared to the employment in 1935 and the production of coal in the corresponding years.

TABLE 3. - Employment in Spanish coal mines

Year	Anthracite	Bituminous	Lignite	Total
Number of workers employed				
1935	4,471	27,741	1,931	34,143
1944	10,083	56,161	12,699	78,943
Production of coal, in metric tons				
1935	649,573	6,296,831	321,424	7,267,828
1944	1,514,009	8,926,702	1,192,600	11,633,511

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Statistics showing the annual production by coal districts are not available, but the increase in the number of mine workers in selected coal-mining provinces is significant as shown in table 4.

TABLE 4. - Employment in coal mines in selected Provinces

Year	Anthracite	Bituminous	Lignite	Total
Province of Oviedo				
1935	181	20,642	-	20,823
1944	1,015	37,027		38,042
Province of Ciudad Real				
1935	-	1,303	-	1,303
1944	-	4,299	-	4,299
Province of Barcelona				
1935	-		726	726
1944	-		3,185	3,185
Province of Teruel				
1935	-	-	664	664
1944	-	-	4,583	4,583

The lignite mines pay a higher wage scale than either the bituminous or anthracite mines; the mining conditions are better; and the mines are near large centers of population such as Barcelona. One of the major causes of the scarcity of mine labor in other provinces is that many miners have moved from the bituminous-coal fields to the lignite mines.

COAL RESERVES

Recent studies of the coal deposits of Spain have caused a sharp reduction in the tonnage estimates of the coal reserves; however, there can be no doubt that the reserves are sufficient to supply Spanish requirements for many years. The most recent estimate of the national coal reserves is as follows:

	Metric tons
Anthracite	140,000,000
Bituminous coal	4,000,000,000
Lignite	8,000,000,000

A newly discovered basin of bituminous coal near Gijon, Province of Oviedo, may increase the bituminous-coal reserves materially; exploration work is in progress, and considerable optimism is prevalent among the State and mine officials as to the size of this basin. This coal deposit is between the present Asturias coal field and the sea coast and will be readily accessible to steel-producing companies at Bilboa.

ACCIDENTS

Province of Oviedo

Official mine-accident statistics for the Province of Oviedo in 1944 include both anthracite and bituminous-coal mines. The total reported tonnage of coal produced[4] in the province for the year follows:

	Metric tons
Anthracite	135,356
Bituminous coal	6,000,506
River coal	141,329
Total	6,277,191

In 1944, 38,142 persons were employed, of which 26,519 were underground employees and 11,623 worked on the surface.

During 1944, 80 fatal accidents occurred; of these, 76 men were killed in bituminous-coal mines, 1 in anthracite mines, 2 in quarries, and 1 in "fabricas" (probably coke plants). The causes of the fatal accidents are listed below:

Cause of accident	Number of persons killed
Falls of rock	29
Explosives	15
Gas and coal dust	14
Transportation	12
Handling materials	4
Falls of persons	4
Other causes	2
Total	80

The production of coal per fatal accident for the Province in 1944 is as follows:

Type of coal	Coal production per fatal accident, metric tons
Anthracite	135,356
Bituminous coal (mostly washed coal)	78,954
All coal	79,674

Sixty-eight serious accidents were reported; of these, 6 were classified as permanent total disability, 28 total temporary disability, and 34 partial disability.

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[4] Most of the bituminous-coal tonnage reported is on a washed-coal basis.

The accidents in the bituminous-coal mines were classified by causes as follows:

Cause of accident	Percent of total accidents	
	Underground	Surface
Electricity	0.01	0.19
Burns	.22	3.48
Falls of objects	.48	1.99
Explosives and fires	.54	.20
Animals	1.07	2.29
Machinery	1.17	4.71
Falls of persons	3.28	7.20
Handling materials	3.56	8.38
Other causes	3.85	4.11
Transportation	9.55	30.42
Hitting against objects	11.52	20.06
Hand tools	14.64	12.15
Falls of ground	50.11	4.82
Total	100.00	100.00

The severity of the accidents is indicated by the number of days lost time suffered by the workers as a result of the accidents as shown below:

Days lost time as a result of accidents	Percent of total accidents
Up to 7 days	30.98
8 to 14 days	31.40
15 to 30 days	23.34
1 to 3 months	12,61
3 to 6 months	1.25
6 to 12 months	.42
Total	100.00

The hours at which the accidents occurred are grouped as follows:

Hour of day accident occurred	Percent of total accidents
8:00 a. m. to 12 noon	40.92
12 noon to 2:00 p. m.	15.42
2:00 p. m. to 6:00 p. m.	23.13
6:00 p. m. to 8:00 a. m.	20.53
Total	100.00

The percentage of total accidents occurring at the different hours of the shift follows:

Hour in shift when accident occurred	Percent of total accidents
First hour	11.44
Second hour	12.96
Third hour	12.77
Fourth hour	14.36

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Hour in shift when accident occurred	Percent of total accidents
Fifth hour	12.07
Sixth hour	12.05
Seventh hour	15.78
Eighth hour	6.33
After 8 hours	2.24
Total	100.00

The age groups of persons injured follow:

Age of person injured, years	Percent of total accidents
14 to 17	7.5
18 to 24	36.5
25 to 34	26.0
35 to 44	18.0
45 to 54	9.0
55 to 64	2.5
65 to 74	.5
Total	100.00

Employment records show that 89.07 percent of the persons injured were employed more than 3 months in the occupation in which they were engaged when injured, and 10.93 percent had worked a lesser time.

Province of Barcelona

In April 1944, a coal-dust explosion in the Clara mine (a lignite mine) at Aspa caused the death of 34 men.

Province of Murcia

A major accident occurred at the Concilio mine of the Sociedad Minero-Metalurgica Zapata Portman on December 12, 1944. A cage in one of the shafts fell, killing 5 men, seriously injuring 6 men, and slightly injuring 4 others.

PRODUCTION

The political upheavals of Spain have had a marked influence on the coal-mining industry; the type of government has changed several times in recent years, and, in many cases, the foreign policy has made long-range planning impossible.

The annual production of one coal-mining company for a period of 20 years is shown below, and the type of government over the same period is also tabulated:

Year	Production of washed coal, metric tons	Type of government
1925	478,000	Monarchy
1926	547,000	do.
1927	509,000	do.
1928	500,000	do.
1929	585,000	do.
1930	585,000	do.
1931	568,000	Republic (Rivera)
1932	506,000	do.
1933	479,000	do.
1934	446,000	Revolution
1935	542,000	do.
1936	250,000	do.
1937	47,000	Mine in possession of communists
1938	395,000	Franco
1939	468,000	do.
1940	596,000	do.
1941	632,000	do.
1942	686,000	do.
1943	725,000	do.
1944	787,000	do.

According to some mine officials, the larger annual production under the regime of General Franco is caused by the Government policy of requiring the miners to work more steadily. Fewer holidays are permitted, and the number of hours worked per day by the underground employees has been increased; this is offset to some extent by the labor shortage caused by the conscription of young men to serve in the army.

For many years Spain imported a substantial tonnage of coal from Great Britain and exported a large part of the citrus crop to England. This Government policy limited the expansion of the coal industry, and some fear is expressed by mine officials that the same policy may prevail in the future which would make it impossible to maintain the present high mine production.

SUMMARY

The coal mines of Spain have become a very important part of the economy of Spain because of the disruption of coal imports on account of the war. The domestic production has nearly doubled in 6 years time and could be increased.

Some of the factors preventing a substantial increase in coal production are:

1. Lack of experienced miners.
2. Lack of compressed-air equipment.

3. Lack of new mining machinery and spare parts.
4. Lack of sufficient electric power.
5. Lack of stability in Government policy which prevents long-range planning and development.

The ventilation of the working faces at most mines is inadequate; better distribution of the ventilating-air currents probably would assist in increasing production.

Exemption from conscription to the army for young men engaged in coal mining would help alleviate the present labor shortage.

The national coal reserves are sufficient to supply Spanish requirements for many years. The newly discovered bituminous-coal deposit near Gijon may increase the bituminous-coal reserves substantially and provide a source of better-quality coal.

The full development of the domestic sources of coal is vitally important to the economy of Spain; the mining companies are well financed and can expand the industry if the Government policy becomes stable enough to permit long-range planning and development.